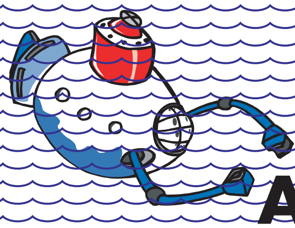


A Bight is Born

Focus

The origin and structure of the southeast coastline and continental shelf (South Atlantic Bight)

Grade Level

9 -12 (Earth Science)
(may be adapted to 7th-8th grade Earth Science Standards)

Focus Question

What is the South Atlantic Bight and how was it formed?

Learning Objectives

Students will sequence and model the events leading to the formation of the southeastern coast of the United States, including the formation of the South Atlantic Bight.

Students will examine what forces have changed the structure of this area over geologic time, predict what changes are yet to occur and how these changes have and may affect the populations living in this area, including man.

Additional Information for Teachers of Deaf Students

In addition to the words listed as Key Words, the following words should be part of the vocabulary list.

Supercontinent
Continents
Cenozoic
Eurasian
Continental shelf
Lapetus
Limestone
Taconic Orogeny
Microcontinent
Collisions
Alleghenian Orogeny
Equator
Piedmont
Monadnocks
Rift basins
Erosion
Coastal
Volcanic
Sediment
Continental shelf
Regresses
Ecosystems

The words listed as key words are integral to the unit. There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful. This activity presents a great deal of new material and requires a large amount of reading and attention. Many new words which might be unfamiliar are included. This activity is best conducted as a review or as an activity after the concepts have been taught. It could take a 90-minute time block to complete.

The script that is used should also be given as a handout for the students to use as a review after the activity. During the activity it reads: „I will read each event once while you listen. I will read it a second time while you color and label your model∑.‰ You may need to read it twice before your students begin the labeling or once before and once after and allow them time to change their drawing, as appropriate. This will increase the time required for the activity.

Materials

- ❒ Teacher's script of "Geologic Events Leading to the Formation of the Southeastern U.S." (make one copy) Attachment 1
- ❒ Model Sheet #1 "The Breakup of Pangaea" (make one copy per student, make one copy on an overhead transparency) Attachment 2
- ❒ Model Sheet #2 "SAB Model" (make one copy per student, make one copy on an overhead transparency) Attachment 3
- ❒ "Geologic Time Flow Chart" Attachment 5 (make one copy per student)
- ❒ Colored pencils – 3 colors (blue, brown and red are suggested colors per student)
- ❒ Transparency pens – 3 colors (blue, brown and red are suggested colors for the teacher's transparency model)
- ❒ Scissors (one pair per student)
- ❒ Gluestick or 3" Scotch tape (one per student)
- ❒ (Optional) - blue construction paper
- ❒ (Optional) - needed for the "Alternate Strategy for Inquiry": Model Sheet #3 "Inquiry SAB Model" (make one copy per student as needed) - Attachment 4 instead of Attachment 3 and 1 pack colored pencils per student (8 colors or more)

Audio/Visual Materials

- ❒ Teacher will need access to overhead projector in order to model the activity while in progress
- ❒ (Optional) Access to a computer with an LCD projector or television with Aver-key hook-up to view these links (see others also listed under resources)

http://www.scotese.com/pangeanim.htm Animation that shows the breakup of Pangaea with continental shelves and mountains color-coded. This is a really good model because the mouse controls the rate of movement and the teacher may simulate the multiple collisions of the North American and African continents by reversing the direction of the movement and then repeating.

http://www.scotese.com/natlanim.htm Animation that shows the seafloor spreading in the North Atlantic Ocean during and after the breakup of Pangaea.

Teaching Time

One 45-minute period

Seating Arrangements

Students work individually

Maximum Number of Students

Typical class size (24-32 or more)

Key Words

Plate Tectonics
Pangaea
Geologic Time (Precambrian, Paleozoic, Mesozoic and Cenozoic eras)
Orogeny
Erosion
mya (million years ago)

Background Information

Through the theory of plate tectonics, scientists explain how the Earth's plates have moved over time. Beginning with the cooling of the Earth's crust and the formation of lithospheric plates prior to the Precambrian period, the Earth's plates have been converging and diverging, or colliding with each other, moving apart or sliding past each other. It is through these processes that mountains are built (called orogeny or mountain-building episodes), volcanic arcs develop, and oceans are created and destroyed, leading eventually to the geography of the world as we know it today with seven continents and five major oceans in their current positions. Scientists are able to piece together ancient evidence to sequence the events leading to our modern configuration. The study of ancient evidence includes such branches of science as paleoclimatology, paleogeology and paleobiology ("paleo" meaning ancient.) This evidence includes, but is not limited to, the study of fossil animals and plants, paleomagnetic trends in rocks, the ages of rocks that form mountain chains and ancient glaciation. We have an understanding of how the plates of the Earth have moved over the last millions of years and can predict how they will continue to move. Using current evidence and theories, students will focus on the sequence of geologic events leading to the formation of the southeastern United States, including the South Atlantic Bight, the coastal margin region of the continental shelf that stretches from Cape Hatteras, North Carolina to Cape Canaveral, Florida.

Learning Procedure

Students will use paper cut-outs to model the sequence of events that has led to the current configuration of the southeastern United States. The teacher will also model the activity step-by-step on the overhead. To make this activity more inquiry-based, an "Alternate Strategy for Inquiry" is included as Extension #2.

*NOTE: This activity could easily follow an investigation of Pangaea. It would be helpful, though not necessary, if students already have a background understanding of Pangaea and the geologic time scale. On the other hand, this activity could be used to introduce the concept of geologic time and/or plate tectonics.

Part I: Distribute one copy of the Model Sheet #1 "The Breakup of Pangaea" per student. (Attachment 2)

Instruct students to:

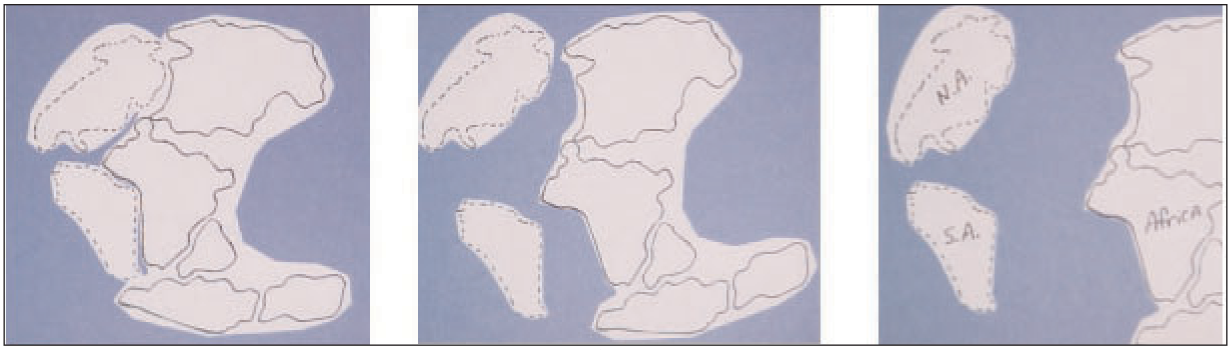
1. Cut the paper in half at the solid horizontal line. Save the bottom half for later.
2. (Top half) Cut apart the pieces on the dotted lines only, placing the pieces back in the same positions on the model and wait for further instructions. Explain that for the purposes of this activity, we will only be focusing on what is happening with the southeastern United States. For this reason, this is not a Pangaea activity and the breakup of the entire supercontinent of Pangaea is not represented with our model.

Extension #1: If the teacher would like to go into a discussion about Pangaea at this time, the animations listed under "Audio/Visual Materials" show the breakup of Pangaea into today's continents. Attachment 2 could be used to model this by having students label and cut out all continents along the solid lines and move them according to the animation sequence.

3. Label the North American, African and South American continents. (Model on the overhead with the transparency made from Attachment 2).
4. Teacher reads from the script (Attachment 1) under the subheading "Breakup of Pangaea." (See pictures below for the placement of the model pieces).

"Many of you have heard of the supercontinent that once existed 270 million years ago. (Allow for student responses.) It is named Pangaea. At your desk, you are looking at a model of Pangaea and the positions of today's continents as scientists believed they looked back then. However, where were the continents before Pangaea was formed? (Allow for student responses.) It is important to understand that the continents did not begin as one supercontinent, but had moved into those positions over millions of years during the Late Precambrian and Early Paleozoic Eras. Do we live on Pangaea today? (Allow for student responses.) Of course not! After the formation of Pangaea, the continents continued to move, breaking apart during the Mesozoic Era and moving into their current positions in today's era, the Cenozoic. Where were the North and South American continents during Pangaea? (Allow for student responses.) (Answer: Connected to each other and the African continent.) Part of North America was also connected to the Eurasian plate. Using your model, demonstrate how you think the North American and South American continents moved during the breakup of Pangaea. (Allow for students to participate. Next, model movement on overhead.) How do scientists explain the movement of the continents? (Allow for student responses.) (Answer - By plate tectonics.) Our activity today will focus on the movement of the North American and African continents. Our question is: What geologic events led to the formation of the southeastern United States, and more specifically, the South Atlantic Bight? This is the region being explored by the NOAA Islands in the Stream Expedition 2002. You will use a model to illustrate and label the sequence of events."

Extension #2 "Alternate Strategy for Inquiry": To make this activity more inquiry-based and less teacher-led, skip the next section. Distribute the Model Sheet #3 "Inquiry SAB Model" (Attachment 4) instead of Model Sheet #2. The "Geologic Time Flow Chart" (Attachment 5) may be distributed, or students may be required to create their own record of the time scale with a description of events. Read the sequence of events as given in the next section, but do not model the events on the overhead. If students create their own flow chart, model the first entry with them after the first event is read. Allow students to use the 8-pack of colored pencils to illustrate and label their own interpretation of the events on the model sheet. They will choose how many and what kind of colored pencils to use and use their best discretion in creating the model. Note that the outline of the continental shelf (the South Atlantic Bight) is not given to them. At the end of the sequence of events, have students briefly share their models at their team tables. Monitor and choose a few to share with the class. Allow volunteers to have a chance to share as well. Point out the different interpretations and encourage student discussion of possible reasons for the discrepancies. Finally, use the



Note that the shape as well as the position of the continents will change over time.
Point out that the model does not show the change in shape.

overhead model to illustrate the actual events and formation of the South Atlantic Bight, instructing students to make a list of changes needed to make their model more accurate. (Do not allow students to change the original model! Hang them on display to communicate their interpretations with other teachers and students in the school).

Part II: Distribute a copy of Model Sheet #2 "SAB Model" (Attachment 3) and "Geologic Time Flow Chart" (Attachment 5) to each student.

Instruct students to:

1. Cut out and color the rectangle BLUE from the bottom half of Model Sheet #1 that we used earlier.

NOTE: If blue construction paper is available, use the white rectangle as a pattern to cut a blue rectangle from the construction paper. Alternatively, copies of Attachment 2 may be made on blue copy paper, if the teacher does not mind having a blue Pangaea model for Part I of the activity.

2. Cut out the African continent on its solid outline from Model Sheet #2. Do not cut the dotted line. Point out that this model shows only a fraction of the northwest corner of the African continent.
3. Glue or tape one end of the blue rectangle under the African continent. Line up the edge of the rectangle with the dotted line shown on the African model.
4. Cut out the southeastern United States on the solid outline. Cut a slit along the coastline at the dashed line (between the X's).
5. Insert the other end of the blue rectangle into the slit on the southeastern United States. Slide the two continents together until they meet. Await further instructions.
6. Distribute "Geologic Time Flow Chart" (Attachment 5). Teacher reads from the script (Attachment 1) under the subheading "Instructions."

"I am going to read to you the sequence of events that have resulted in the formation of the southeastern United States and the South Atlantic Bight over the last hundreds of millions of years, beginning even before Pangaea was formed. You will use your colored pencils to illustrate these events on your model. The blue represents water, red will represent mountains and brown will represent sediments formed from erosion. Notice that you have been given an outline of the shape of these continental states and their continental shelf. However, it is important to note that the southeastern United

States DID NOT YET EXIST over 800 million years ago in the Precambrian Era, the time at which we will begin this activity. Therefore, we will color the parts of our model as each section is formed (or born). I will read each event once while you listen. I will read it a second time while you color and label your model. After each of you has changed your model, I will model the changes on the overhead. As each event is illustrated on the model, you will create a geologic time scale using the flow chart I have given you. The geologic era and the time (millions of years ago) are filled in for you. Be sure to record a description of the event and the effects on the geography and/or geology of the southeastern United States. You will label the section of the model that corresponds to the flow chart with its letter (A, B, etc. as listed on the flow chart)."

Note: It is important that students make their own interpretation before the teacher models the changes. If students are simply waiting to copy the teacher's overhead model, then discontinue the overhead model. Constantly monitor that students remember to record events in their flow chart as well as coloring and labeling their models. The first event should go slowly, with the teacher checking that all students have colored the appropriate section of the model, recorded a description of the event on the flow chart and labeled the model section with an "A" that corresponds to the flow chart. This should be done before putting the model on the overhead. After the first event and students understand the task before them, the pace will pick up.

7. Teacher reads from the script (Attachment 1) under the subheading "Sequencing the Events." (See pictures below for the placement of the model pieces, possible color coding and labeling of events).

Adapted from Murphy, Dr. Carolyn Hanna. Carolina Rocks! The Geology of South Carolina. Orangeburg, SC: Sandlapper Publishing Co., Inc., 1995.

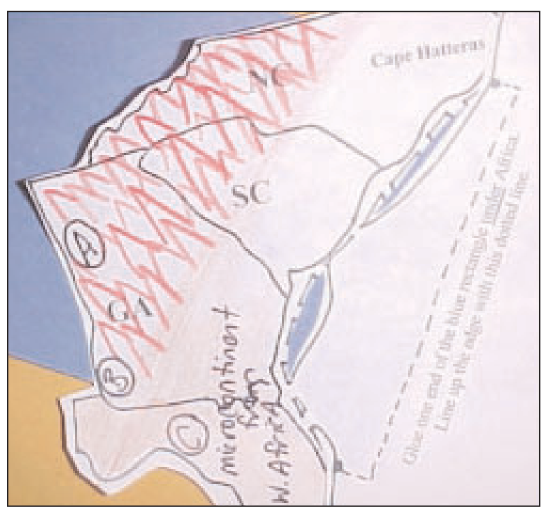
A. Precambrian Era (800 mya) "Grenville Orogeny"
Scientists believe that North America has been joined with Africa at least once and probably several times well before the time of Pangaea. However, 800 mya North America separated from the African continent, leading to the formation of an ancient ocean (Iapetus), creating the first continental shelf along the southeastern United States. But, there is a catch. The landforms that now form the southeastern United States did not yet exist. The limestone sediment that formed that ancient continental shelf is found in the uppermost northwest corner of South Carolina, northern Georgia and across North Carolina in what is now the oldest part of the Blue Ridge Mountains. Southern Georgia and Florida have not yet been formed. This is the earliest mountain-building episode for the southeastern United States, and is named the "Grenville Orogeny." Orogeny is a scientific term meaning "mountain-building event or episode in Earth's geologic history."

B. Early-Middle Paleozoic Era (470-440 mya) "Taconic Orogeny"

Pangaea has begun to form about 560 mya, leading to North America and Africa to pull together and the ancient Iapetus Ocean to close up. When these two continents come together, an island arc (which may have actually been a microcontinent) called the "Avalon terrain" gets welded onto the North American continent, forming the inner Piedmont in North Carolina, South Carolina and northern Georgia (still no formation of southern Georgia or Florida). Today, we know this area as the Blue Ridge Mountains and their foothills. This period is known as the "Taconic Orogeny." North America and Africa continue to have repeated collisions from 380-340 mya, called the "Acadian Orogeny," in which the Blue Ridge Mountains are built up.

C. Late Paleozoic (330-270 mya) "Alleghenian Orogeny"

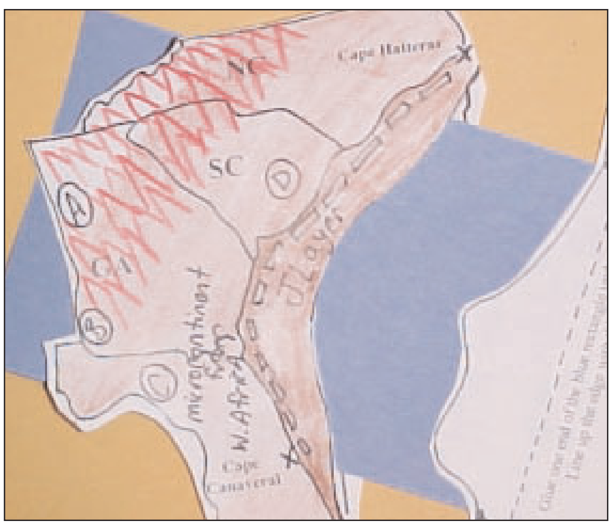
By now, Pangaea is fully formed and the southeastern United States finds itself at Earth's equator. This is the time of the most intensive mountain-building episodes called the "Alleghenian Orogeny." The Piedmont is formed and scientists believe the Blue Ridge Mountains reached as high as 29,000 feet (they now average around 3000 feet), rivaling the height of the Himalayas today. We still find evidence of these ancient mountains in the Piedmont area as "monadnocks" or isolated mountain "hills." However, southern Georgia and Florida are not made of this same Piedmont rock. As Pangaea begins to break up, a microcontinent or large piece of West Africa breaks off and welds onto North America, forming the beginning of these two states.



Note that the mountains are eroding. Sediment (brown) is starting to be deposited in front of the mountains in SC, GA, and NC.

D. Early Mesozoic (180 mya) J Layer Forms

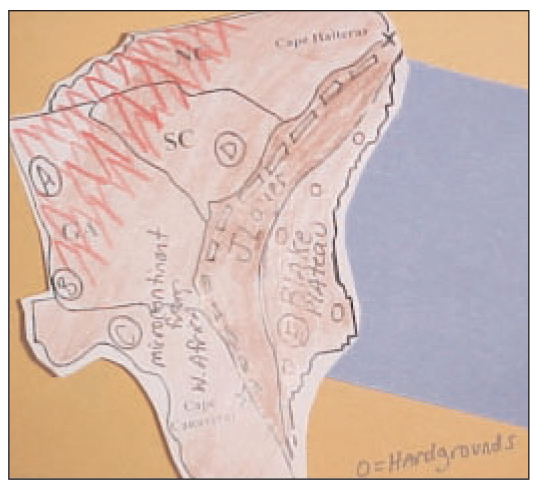
As Pangaea begins to break up after about 70 million years of relative stability, North America and Africa once again pull apart, forming rift valleys between them. These rift basins became filled with sediment from the erosion of the mountains, and helped to fill in the sandhills and coastal plains of North Carolina, South Carolina and Georgia. Because of the great stress that happens when a continent pulls apart (Pangaea), much volcanic activity occurs, and a sheet of volcanic rock called the "J layer" (J stands for Jurassic) spreads over the entire coastal plain and out onto the continental shelf. This layer today is now under hundreds to thousands of feet of eroded sediment from the ancient Blue Ridge Mountains.



Note that a second slit may be cut at the line of the outer shelf. The "ocean" may be reinserted through this second slit, representing the ancient coastline (which today is covered by water as part of the continental shelf.)

E. Late Mesozoic-Cenozoic (140 mya - 5 mya) Sea Level Rises and Falls

As the North American and African continents continue to move apart, the Atlantic Ocean continues to grow at the rate of 1-2 cm a year. Over the last millions of years, the Blue Ridge Mountains continue to erode, dumping hundreds and, in some places, thousands of feet of sediment on the coastal plain and continental shelf. The weight of this sediment and the cooling off of the continent after all that volcanic activity during the Mesozoic causes the southeast coastline to actually sink into the ocean, while elevating the northwest sections of the states. Because of this, sea level rises and limestone is deposited on the coastal plain. As the sea again regresses (sea level lowers), more of the southeast coastline is revealed and



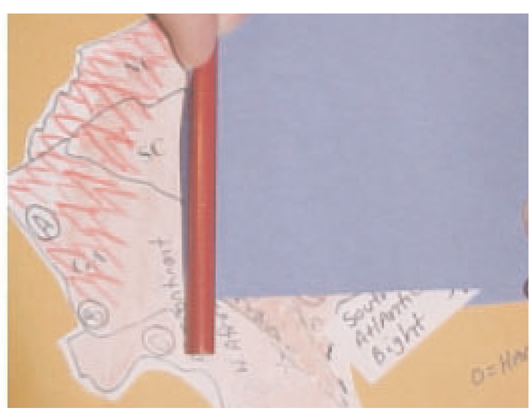
Note that the "ocean" has been removed from the second slit and placed under the entire model piece to represent the next ancient coastline. Students may choose to represent the limestone hardgrounds that are exposed today through the layers of sediment.

rivers deposit sand and clay sediments from the still-eroding Blue Ridge Mountains. The repetition of the rising and lowering sea level over the last millions of years produce a thick limestone layer that extends well out onto the continental shelf. We call this region the Blake Plateau and it extends 200 miles off today's coast. It is covered by sediment, but outcroppings of limestone have been exposed underwater by erosion and are called "hardgrounds."

F. The Gulf Stream (20 mya)

Before the Gulf Stream formed, the "Gulf Trough Current" cut across Georgia and flowed around South Carolina, dumping sediment on the continental shelf. When the Gulf Stream formed about 20 mya, it carved the shape of the continental shelf with its northerly flow and allowed sediment to build up so that the shelf now extends to over 200 miles from the coastline and is 2-3 miles deep in eroded sediment. This area of the continental margin that extends from Cape Hatteras, North Carolina to Cape Canaveral, Florida is called the "South Atlantic Bight." Some questions NOAA scientists hope to answer about the South Atlantic Bight are "What is the limestone hardgrounds' origin? Exactly how old are they and the coral that have formed on them? What ecosystems depend on the hardgrounds?"

After labeling the Gulf Stream and the South Atlantic Bight, students may then reinsert the "ocean" through the original slit on the dashed line to represent the coastline today. This will help them to visualize the coastal margin of the Bight as it is positioned under the water.



Students may roll the end of the "ocean" over a pencil and by rolling and unrolling the blue paper, simulate the repetition of the rising and falling of the sea level.

8. Allow time for review (sample questions are listed in the "Evaluation" section below).

The BRIDGE Connection

http://www.vims.edu/bridge/beachtip1.jpg "Coastal Erosion: Where's the Beach?"

http://www.vims.edu/bridge/archive0799.html "The Seafloor and Below"

The "Me" Connection

For those who live on a coast, whether it is the southeastern coastal United States or another beach somewhere else in the world, the effects of erosion on the community is very obvious. Especially in areas of North Carolina, South Carolina and Georgia, the topics of erosion control and who owns the sand are subjects of hot debate in legislation and community development. Decisions to renourish eroding beaches can cost taxpayers (that is everyone) millions of dollars per project. Students may research a developed coastal area with a high rate of erosion to determine what conservation and restructuring efforts may be costing their family or community, even on a national level.

Connections to Other Subjects

Geography, Language Arts, Art, Ecology, Political Science/Social Studies

Evaluation

Monitoring of student participation during the modeling of the sequence of events is a must to be certain students do not fall behind or get lost.

A formal evaluation of the "Geologic Time Flow Chart" may be useful in encouraging students to remain on task and to monitor student understanding.

Review Questions to be used at the end of the activity include but are not limited to:

1. What are the two main processes that formed the southeastern United States and the South Atlantic Bight? (erosion and mountain-building)
2. How did these two processes work together to build the different regions of the southeast? (mountain-building: Blue Ridge Mountains and Piedmont, erosion of these mountains-coastal plain and continental shelf)
3. How would the geography of this area be different if erosion had not affected the Blue Ridge Mountains? How would life be different for people living in surrounding areas? Would it be better? Why or why not? (South Carolina, North Carolina and Georgia geography would probably be Himalayan-sized mountains with no flat, sandy coastal plain or beaches. The continental shelf would be all limestone hardground over a layer of volcanic rock.) (Student answers vary).
4. What is so significant about the southeastern continental shelf that it would earn the name "South Atlantic Bight?" (It is one of the widest continental shelves in the world, extending over 200 miles off the coast. Its limestone hardgrounds form special ecosystems. It has the unique shape of a deep curve).
5. Why does the South Atlantic Bight not extend all the way down to Florida? (Florida formed later than North Carolina, South Carolina and Georgia, so it has had

less sediment build-up from mountains eroding. Also, the current that existed before the Gulf Stream used to cut across Georgia, above Florida, bypassing that state as it dumped its sediment off the coasts of Georgia and South Carolina.)

6. Where do you predict the southeastern United States to be in 5 million years? 500 million years? Why? (Student answers will vary but should include some understanding that North America will continue to move in a southwest direction away from Africa as the Atlantic Ocean continues to expand. Scientists estimate we may meet Asia in 50 million years).
7. What changes do you think will occur on this coastline in your lifetime? How will that affect the people living in this area? (Student answers will vary but may include a discussion of erosion, sea level rising or falling, etc.) See The "Me" Connection.

Extensions

In addition to Extensions #1 and #2 inserted where appropriate in the Learning Procedure, students may visit the Project Oceanica web site later in the school year to investigate the latest theories of the limestone hardground origins based on samples taken from the South Atlantic Bight mission at http://oceanica.cofc.edu/

Students may extend their investigation to the Mid-Atlantic Region. http://csmres.jmu.edu/geollab/vageol/vahist/index.html This site is an extensive history of the geological evolution of the Mid-Atlantic Region (especially Virginia). It includes a link to a plate tectonics primer.

Resources

Murphy, Dr. Carolyn Hanna. *Carolina Rocks! The Geology of South Carolina*. Orangeburg, SC: Sandlapper Publishing Co., Inc., 1995. Excellent source for teachers and students who would like to educate themselves about all the nitty-gritty details of the geological formation of SC and parts of the other southeastern states. Most of the information in the teacher's script came from this book.

http://earth.usc.edu/~stott/Catalina/Oceans.html See "Ancient Current Systems" for illustrations of the changes in ocean circulation during the time of the breakup of Pangaea.

http://www.pangaea.de/Links/ Just about every organization associated with global change is listed here!

http://www.scotese.com/newpage13.htm This page has links to a variety of good animations including global geologic and climatic changes (including the two links listed under Audio/Visual Materials).

http://pubs.usgs.gov/publications/text/historical.html Tutorial on plate tectonics, featuring Pangaea.

http://www.enchantedlearning.com/subjects/dinosaurs/glossary/Pangaea.shtml A teacher-friendly site about plate tectonics and Pangaea. It also discusses fossil evidence.

http://webspinners.com/dlblanc/tectonic/pangea.shtml This site offers more background on the formation of Pangaea and goes into detail about the different collisions.

http://cva.morehead-st.edu/landscape/mountain_ranges.html
A map showing today's position of the Blue Ridge Mountains

National Science Education Standards

Science as Inquiry - Content Standard A:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Earth and Space Science-Content Standard D:

- Structure of the Earth system
- Earth's history

Activity developed by Dina Ledford, Fort Dorchester High School, Charleston, SC

Attachment 1
Teacher's Script

Adapted from Murphy, Dr. Carolyn Hanna. Carolina Rocks! The Geology of South Carolina. Orangeburg, SC: Sandlapper Publishing Co., Inc., 1995.

Breakup of Pangaea

"Many of you have heard of the supercontinent that once existed 270 million years ago. (Allow for student responses.) It is named Pangaea. At your desk, you are looking at a model of Pangaea and the positions of today's continents as scientists believed they looked back then. However, where were the continents before Pangaea was formed? (Allow for student responses.) It is important to understand that the continents did not begin as one supercontinent, but had moved into those positions over millions of years during the Late Precambrian and Early Paleozoic Eras. Do we live on Pangaea today? (Allow for student responses.) Of course not! After the formation of Pangaea, the continents continued to move, breaking apart during the Mesozoic Era and moving into their current positions in today's era, the Cenozoic. Where were the North and South American continents during Pangaea? (Allow for student responses.) (Answer - Connected to each other and the African continent.) Part of North America was also connected to the Eurasian plate. Using your model, demonstrate how you think the North American and South American continents moved during the breakup of Pangaea. (Allow for students to participate. Next, model movement on overhead.) How do scientists explain the movement of the continents? (Allow for student responses.) (Answer - By plate tectonics.) Our activity today will focus on the movement of the North American and African continents. Our question is: What geologic events led to the formation of the southeastern United States, and more specifically, the South Atlantic Bight? This is the region being explored by the NOAA Islands in the Stream Expedition 2002. You will use a model to illustrate and label the sequence of events."

Instructions

"I am going to read to you the sequence of events that have resulted in the formation of the southeastern United States and the South Atlantic Bight over the last hundreds of millions of years, beginning even before Pangaea was formed. You will use your colored pencils to illustrate these events on your model. The blue represents water, red will represent mountains and brown will represent sediments formed from erosion. Notice that you have been given an outline of the shape of these continental states and their continental shelf. However, it is important to note that the southeastern United States DID NOT YET EXIST over 800 million years ago in the Precambrian Era, the time at which we will begin this activity. Therefore, we will color the parts of our model as each section is formed (or born). I will read each event once while you listen. I will read it a second time while you color and label your model. After each of you has changed your model, I will model the changes on the overhead. As each event is illustrated on the model, you will create a geologic time scale using the flow chart I have given you. The geologic era and the time (millions of years ago) are filled in for you. Be sure to record a description of the event and the effects on the geography and/or geology of the southeastern United States. You will label the section of the model that corresponds to the flow chart with its letter (A, B, etc. as listed on the flow chart)."

Sequencing the Events

A. Precambrian Era (800 mya) "Grenville Orogeny"

Scientists believe that North America has been joined with Africa at least once and probably several times well before the time of Pangaea. However, 800 mya North America separated from the African continent, leading to the formation of an ancient ocean (Iapetus), creating the first continental shelf along the southeastern United States. But, there is a catch. The landforms that now form the southeastern United States did not yet exist. The limestone sediment that formed that ancient continental shelf is found in the uppermost northwest corner of South Carolina, northern Georgia and across North Carolina in what is now the oldest part of the Blue Ridge Mountains. Southern Georgia and Florida have not yet been formed. This is the earliest mountain-building episode for the southeastern United States, and is named the "Grenville Orogeny." Orogeny is a scientific term meaning "mountain-building event or episode in Earth's geologic history."

B. Early-Middle Paleozoic Era (470-440 mya) "Taconic Orogeny"

Pangaea has begun to form about 560 mya, leading to North America and Africa to pull together and the ancient Iapetus Ocean to close up. When these two continents come together, an island arc (which may have actually been a microcontinent) called the "Avalon terrain" gets welded onto the North American continent, forming the inner Piedmont in North Carolina, South Carolina and northern Georgia (still no formation of southern Georgia or Florida). Today, we know this area as the Blue Ridge Mountains and their foothills. This period is known as the "Taconic Orogeny." North America and Africa continue to have repeated collisions from 380-340 mya, called the "Acadian Orogeny," in which the Blue Ridge Mountains are built up.

C. Late Paleozoic (330-270 mya) "Alleghenian Orogeny"

By now, Pangaea is fully formed and the southeastern United States finds itself at Earth's equator. This is the time of the most intensive mountain-building episodes called the "Alleghenian Orogeny." The Piedmont is formed and scientists believe the Blue Ridge Mountains reached as high as 29,000 feet (they now average around 3000 feet), rivaling the height of the Himalayas today. We still find evidence of these ancient mountains in the Piedmont area as "monadnocks" or isolated mountain "hills." However, southern Georgia and Florida are not made of this same Piedmont rock. As Pangaea begins to break up, a microcontinent or large piece of West Africa breaks off and welds onto North America, forming the beginning of these two states.

D. Early Mesozoic (180 mya) J Layer Forms

As Pangaea begins to break up after about 70 million years of relative stability, North America and Africa once again pull apart, forming rift valleys between them.

These rift basins became filled with sediment from the erosion of the mountains, and helped to fill in the sandhills and coastal plains of North Carolina, South Carolina and Georgia. Because of the great stress that happens when a continent pulls apart (Pangaea), much volcanic activity occurs, and a sheet of volcanic rock called the "J layer" (J stands for Jurassic) spreads over the entire coastal plain and out onto the continental shelf. This layer today is now under hundreds to thousands of feet of eroded sediment from the ancient Blue Ridge Mountains.

E. Late Mesozoic-Cenozoic (140 mya - 5 mya) Sea Level Rises and Falls

As the North American and African continents continue to move apart, the Atlantic Ocean continues to grow at the rate of 1-2 cm a year. Over the last millions of years, the Blue Ridge Mountains continue to erode, dumping hundreds and, in some places, thousands of feet of sediment on the coastal plain and continental shelf. The weight of this sediment and the cooling off of the continent after all that volcanic activity during the Mesozoic causes the southeast coastline to actually sink into the ocean, while elevating the northwest sections of the states. Because of this, sea level rises and limestone is deposited on the coastal plain. As the sea again regresses (sea level lowers), more of the southeast coastline is revealed and rivers deposit sand and clay sediments from the still-eroding Blue Ridge Mountains. The repetition of the rising and lowering sea level over the last millions of years produce a thick limestone layer that extends well out onto the continental shelf. We call this region the Blake Plateau and it extends 200 miles off today's coast. It is covered by sediment, but outcroppings of limestone have been exposed underwater by erosion and are called "hardgrounds."

F. The Gulf Stream (20 mya)

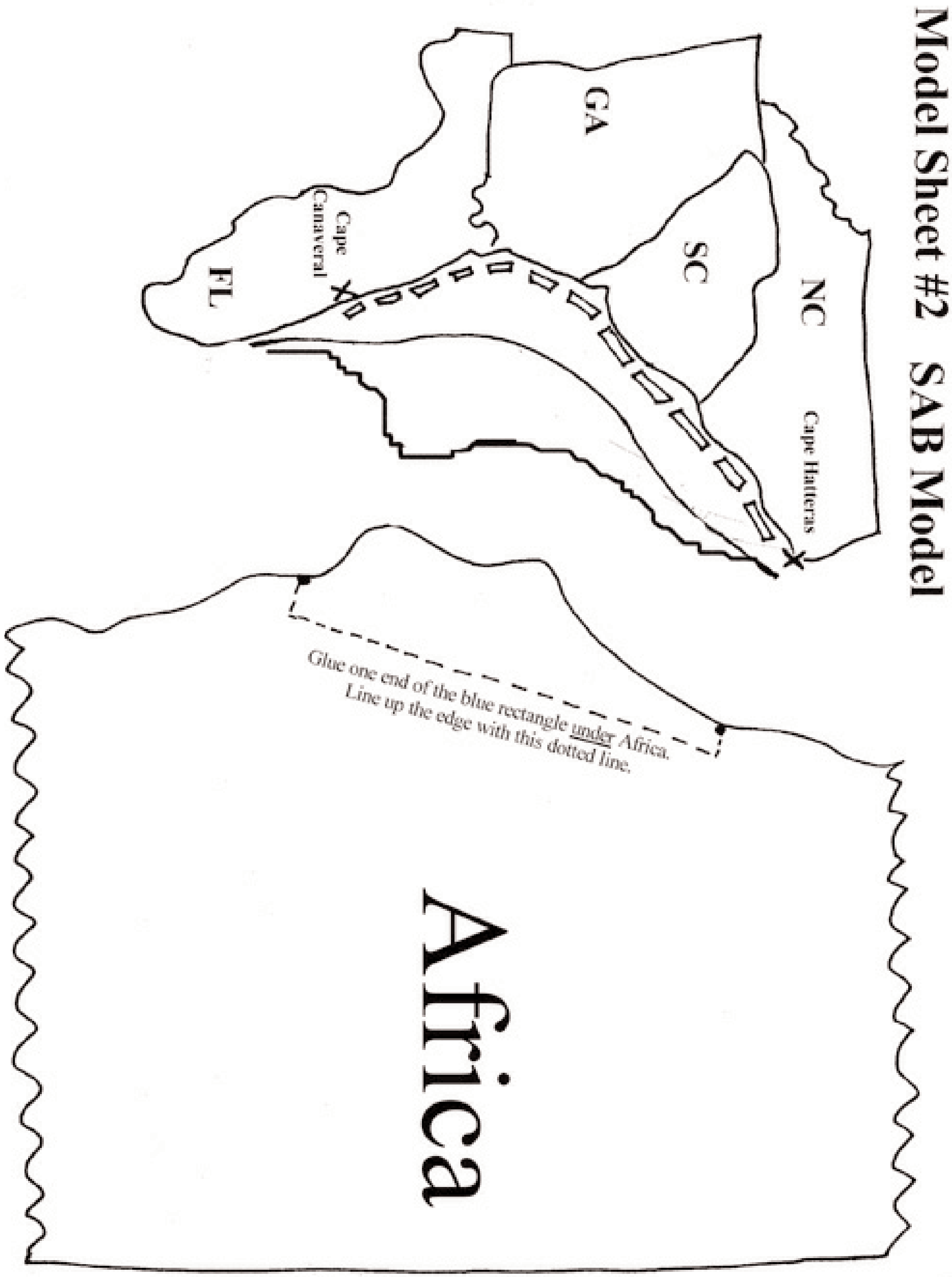
Before the Gulf Stream formed, the "Gulf Trough Current" cut across Georgia and flowed around South Carolina, dumping sediment on the continental shelf. When the Gulf Stream formed about 20 mya, it carved the shape of the continental shelf with its northerly flow and allowed sediment to build up so that the shelf now extends to over 200 miles from the coastline and is 2-3 miles deep in eroded sediment. This area of the continental margin that extends from Cape Hatteras, North Carolina to Cape Canaveral, Florida is called the "South Atlantic Bight." Some questions NOAA scientists hope to answer about the South Atlantic Bight are "What is the limestone hardgrounds' origin? Exactly how old are they and the coral that have formed on them? What ecosystems depend on the hardgrounds?"

Attachment 2

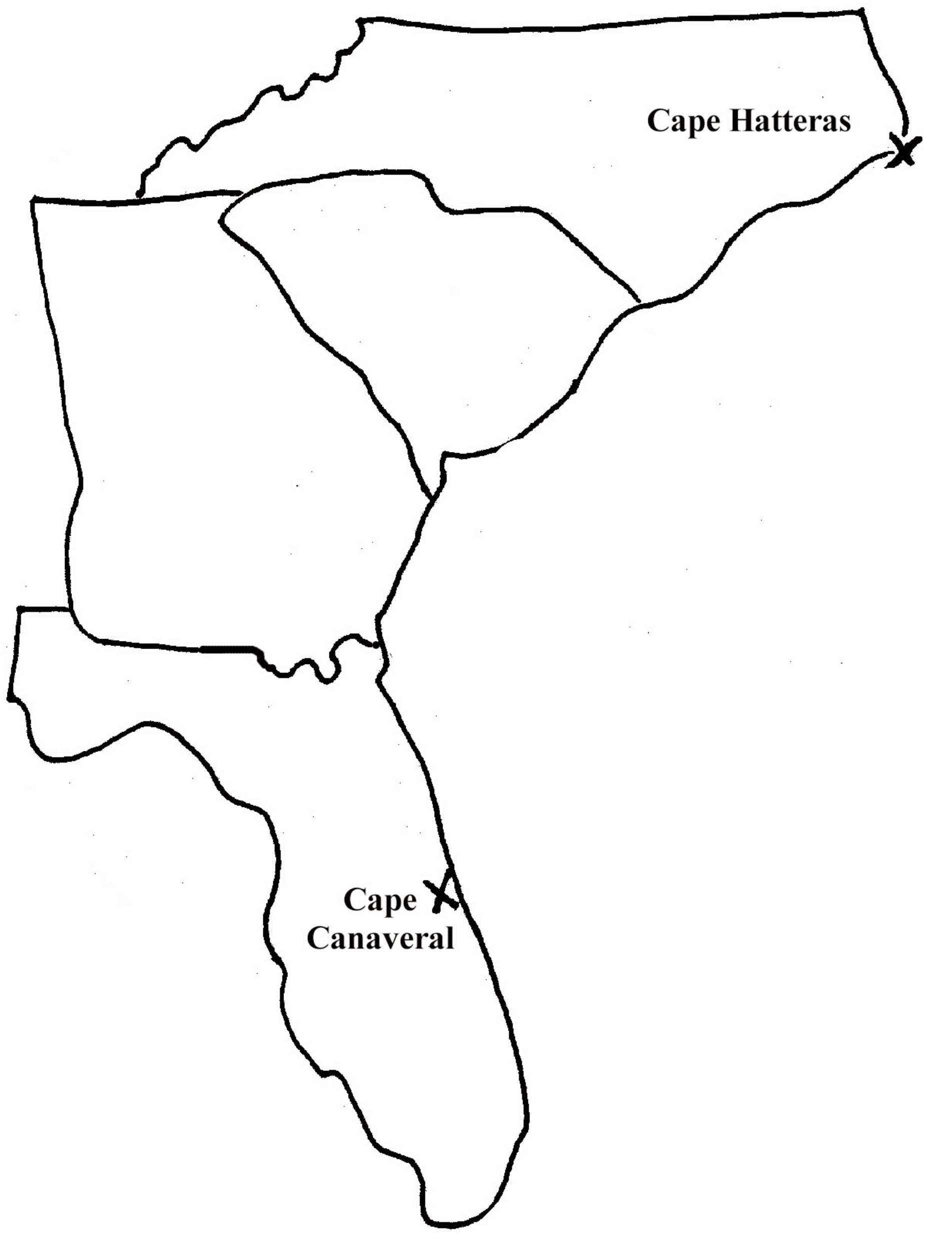
Model Sheet #1 The Breakup of Pangaea

Cut out the rectangle. Color it blue on front and back.

Attachment 3



Model Sheet #3 Inquiry SAB Model



Attachment 4

Attachment 5
Geologic Time Flow Chart

A. Precambrian Era (800mya)
"Greenvill Orogeny"

Event:	Effect on SE US:

B. Paleozoic Era (470-440 mya)
"Taconic Orogeny", "Acadian Orogeny"

Event:	Effect on SE US:

C. Late Paleozoic (330-270 mya)
"Alleghenian Orogeny"

Event:	Effect on SE US:

D. Early Mesozoic (180 mya)
The "J" Layer

Event:	Effect on SE US:

E. Late Mesozoic-Cenozoic (140-5 mya)
Sea Level

Event:	Effect on SE US:

F. Cenozoic (20 mya)
The Gulf Stream

Event:	Effect on SE US:

Notes/Thoughts/Inspirations